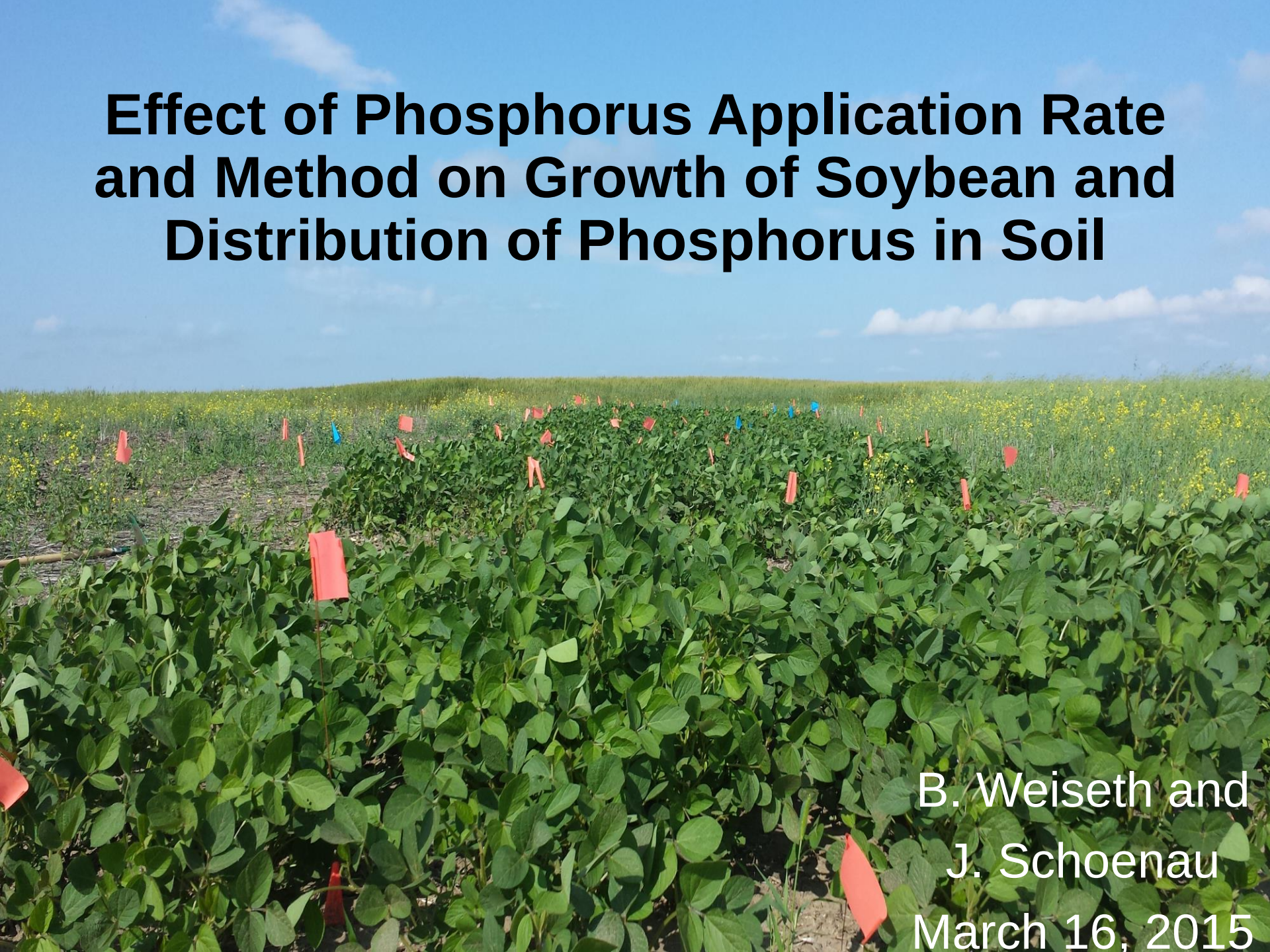
Effect of Phosphorus Application Rate and Method on Growth of Soybean and Distribution of Phosphorus in Soil



B. Weiseth and
J. Schoenau

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Introduction

Apparent dichotomy in Soil Test Phosphorus (STP) levels in agricultural soils on the prairies.

Low STP: Soil P depletion. Potential cap on yield.

High STP: Potential for water quality degradation.

Careful P management needed!!

What is influence of rate and method of application of P fertilizer?

Crop in My Studies: Soybeans

Why Soybeans?

- Emerging crop in Saskatchewan
- Little information on response of short-season soybean to P fertilization on prairies.

Study 1: Effect of Varying Rates of Seed-Placed Fertilizer P on Soybean Seedling Emergence and Biomass Yield.

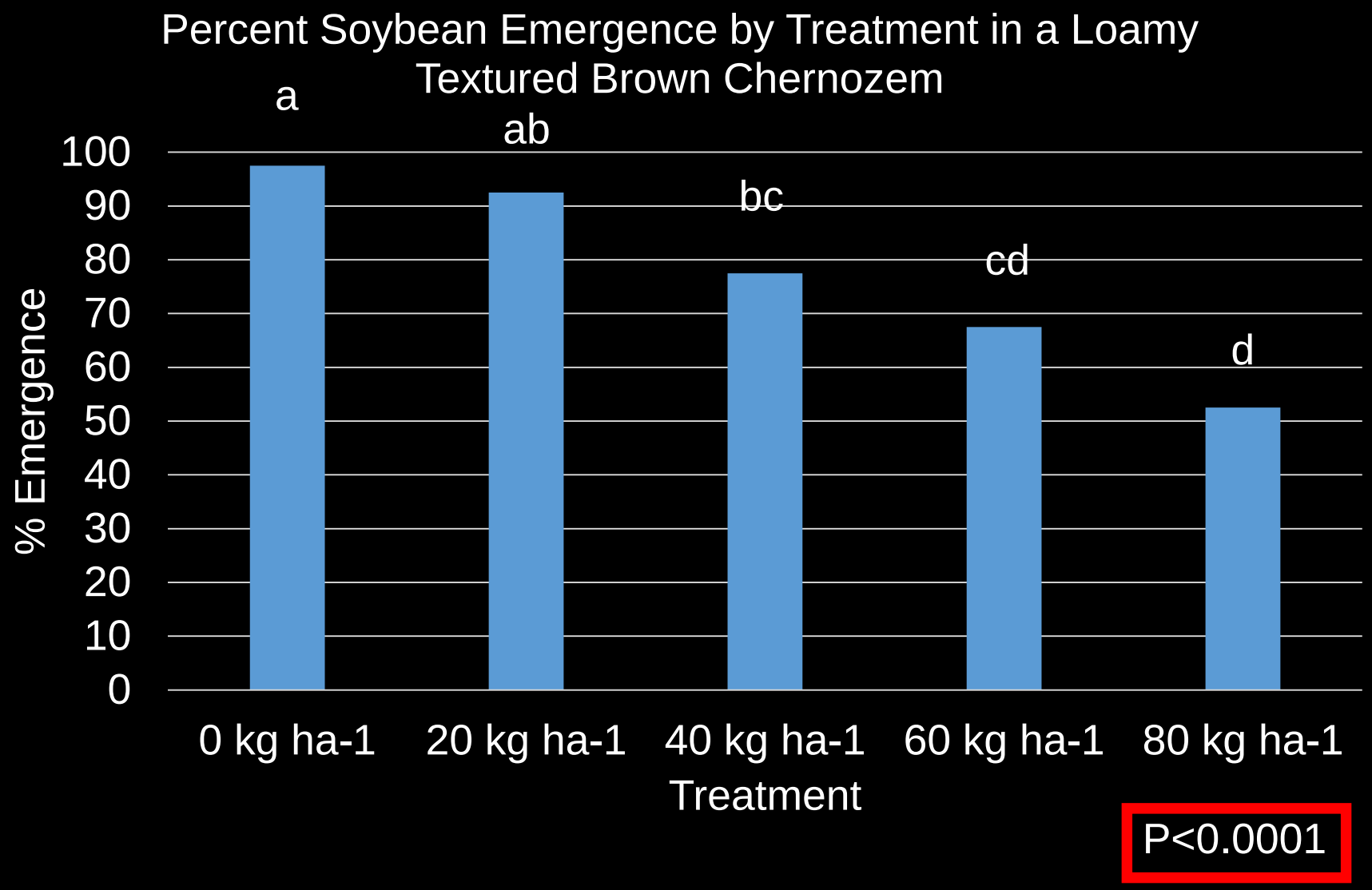
Introduction

Table 1. Balance between seed-placed P addition and P removal for various crops grown on the Canadian prairies.

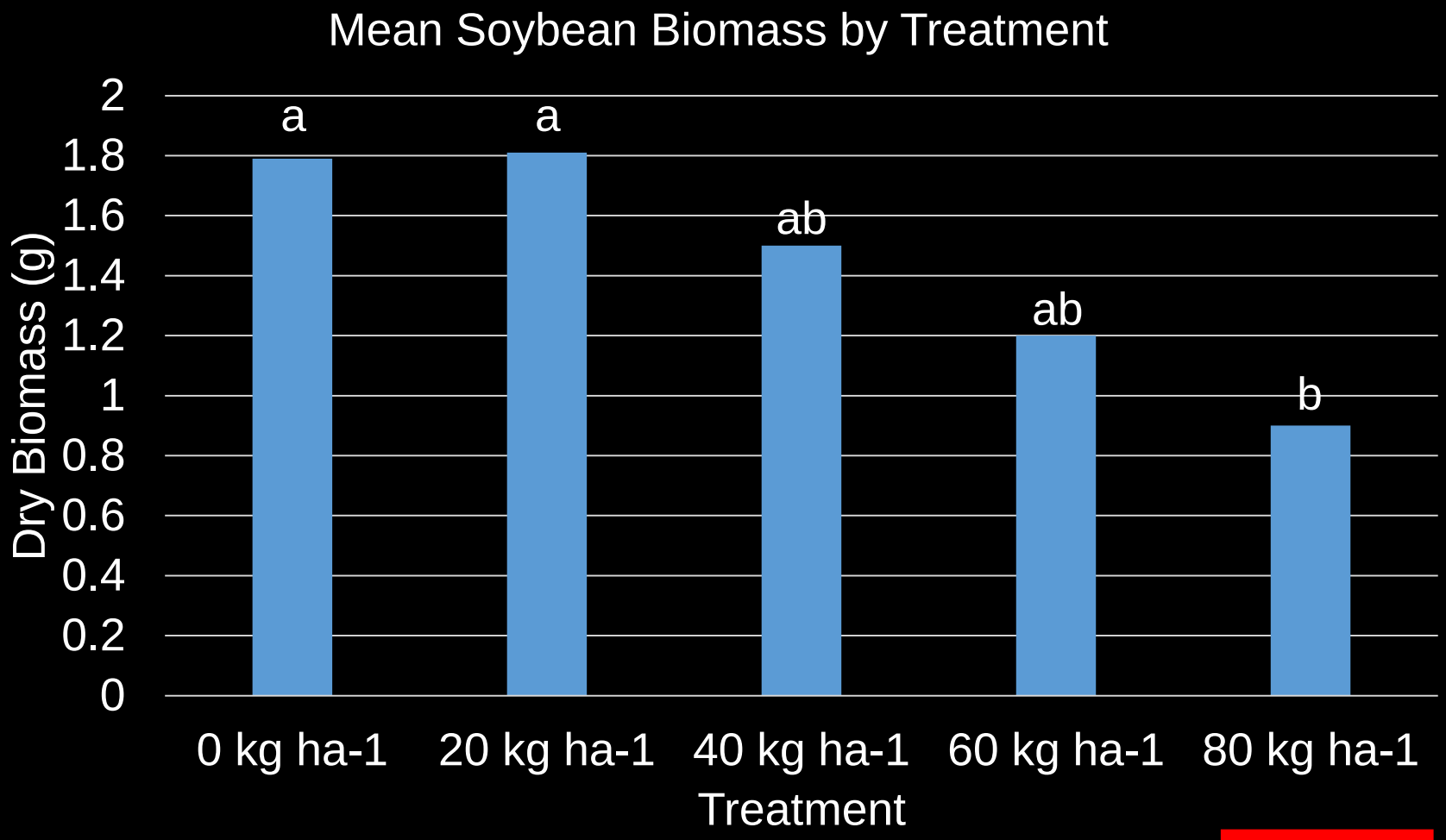
Crop	Yield (bu/ac)	Seed Limit (lb/ac)	Removal (lb/ac)	Net Effect (lb/ac)
Soybean	40	10	32	-22
Canola	40	20	40	-20
Wheat	40	50	29	+21

Adapted from Grant (2012).

Results


Percent Soybean Emergence by Treatment in a Loamy Textured Brown Chernozem
a
ab
bc
cd
d
100
90
80
70
60
50
40
30
20
10
0
% Emergence
0 kg ha-1
20 kg ha-1
40 kg ha-1
60 kg ha-1
80 kg ha-1
Treatment
P<0.0001

Results



P=0.002

Discussion

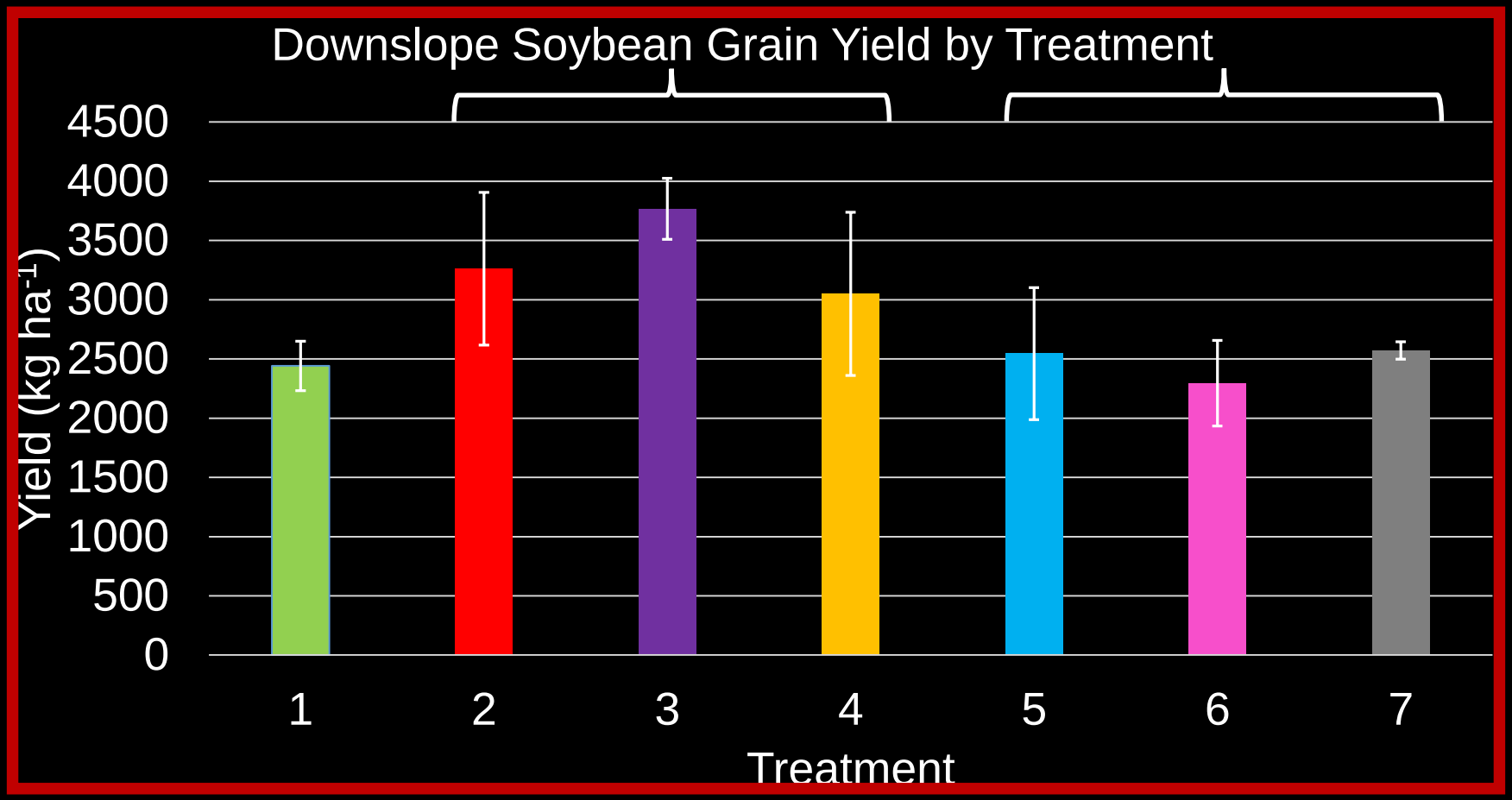
- Application of fertilizer P in excess of 20 kg P_2O_5 ha^{-1} significantly reduced emergence.
- Results are in agreement with studies conducted at field scale in Manitoba (Kostuik et al., 2013).
- However, soybean biomass production was negatively affected only when fertilizer P was applied at 80 kg P_2O_5 ha^{-1}.
- Kostuik found that fertilizer P application at 40 kg P_2O_5 ha^{-1} did not negatively affect soybean biomass production or grain yield.
- Current recommendations for safe rates of seed-placed fertilizer P for soybean may need to be revisited.

Study 2: A Field Study of the Effect of Fertilizer Application Rate & Method on Soybean Yield and Residual Soil P Distribution.

Treatments

- 1) No P fertilizer and seed placed NH_4Cl to account for N in Monoammonium Phosphate (11-52-0);
- 2) Seed placed P at 20 kg P_2O_5 ha^{-1};
- 3) Banded P at 20 kg P_2O_5 ha^{-1};
- 4) Broadcast P at 20 kg P_2O_5 ha^{-1} with incorporation;
- 5) Broadcast P at 20 kg P_2O_5 ha^{-1} without incorporation;
- 6) Broadcast P at 40 kg P_2O_5 ha^{-1} without incorporation; and
- 7) Broadcast P at 80 kg P_2O_5 ha^{-1} without incorporation.

Results



MK P = 9ppm

Treatment Key

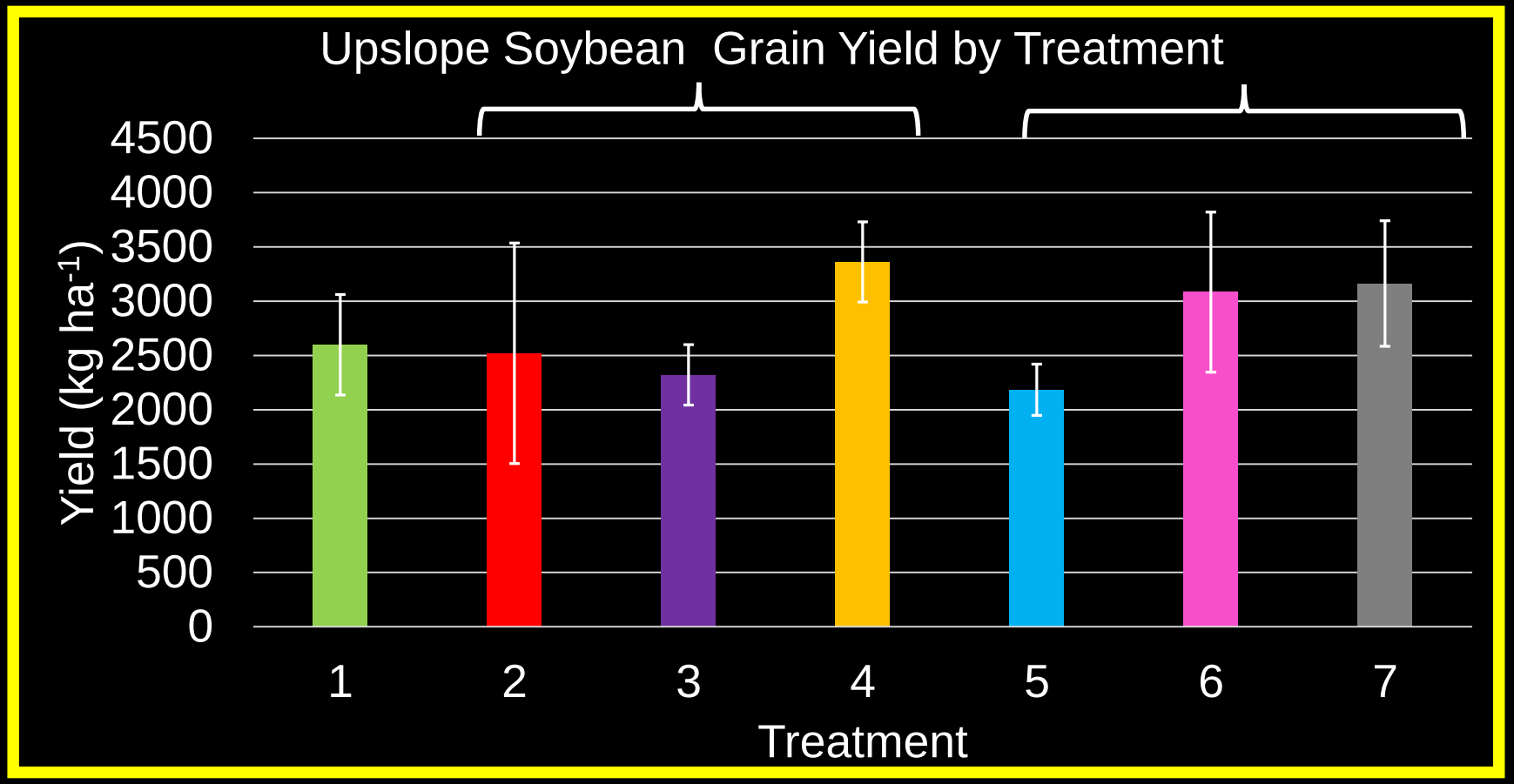
1C 2SP 3DB 4B/I 5B 6B(40) 7B(80)

SEM	P Value
454.52	0.12

Results

Trt	C	SP	DB	B/I	B (20)	B (40)	B (80)
	----------P Value----------						
C	--	0.271	**0.007**	0.431	0.868	0.737	0.580
SP	0.271	--	0.494	0.830	0.432	0.239	0.363
DB	**0.007**	0.494	--	0.367	**0.093**	**0.016**	**0.004**
B/I	0.431	0.830	0.367	--	0.590	0.370	0.539
B (20)	0.868	0.432	**0.093**	0.590	--	0.719	0.966
B (40)	0.737	0.239	**0.016**	0.370	0.719	--	0.504
B (80)	0.580	0.363	**0.004**	0.539	0.966	0.504	--

Results



MK P = 5 ppm

Treatment Key

1C 2SP 3DB 4B/I 5B 6B(40) 7B(80)

SEM	P Value
584.75	0.73

Discussion

Soybean yield response to seed-placed, banded P in downslope. In-soil P placement superior to broadcast.

- Agrees with our general understanding of agronomic BMP's for P placement for small grains.

Other Studies in U.S.

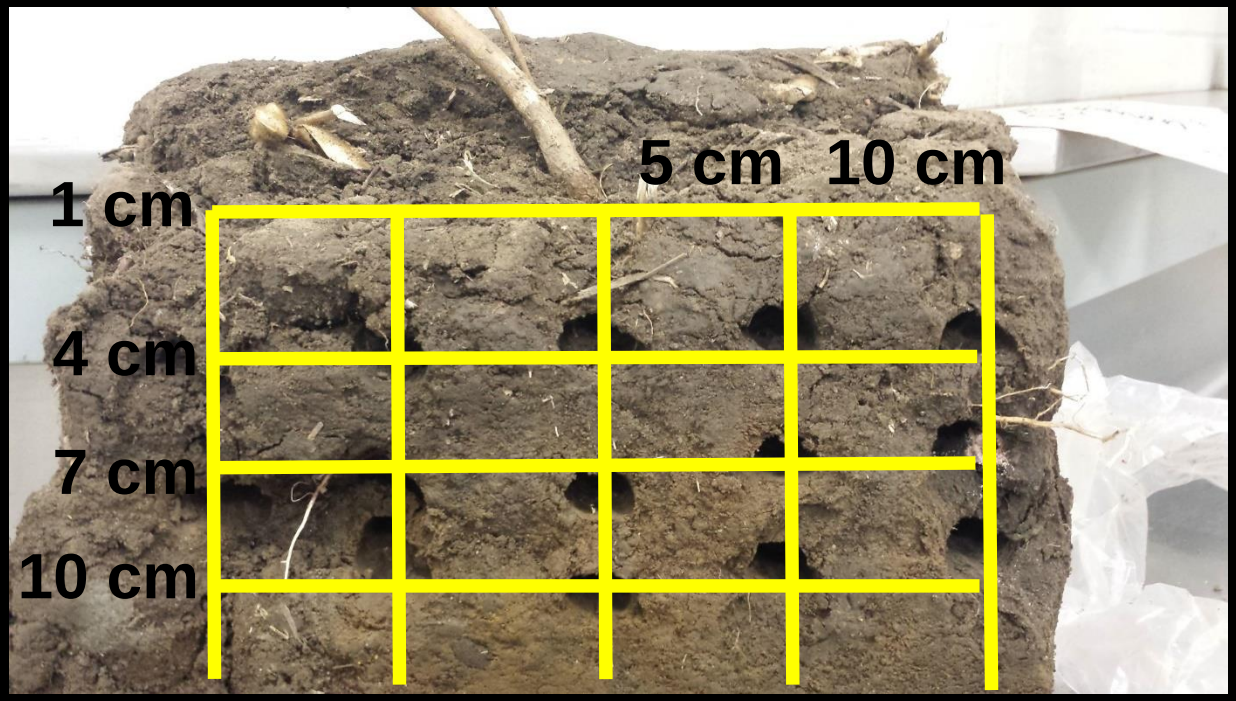
- Soybean yield responsive to P fertilization when STP was < 19 mg kg^{-1} (Bray P_i) (Borges and Mallarino, 2003).
- Banded P resulted in increased soybean yield compared to broadcast application (Hairston et al., 1990).

Apart from yield effects of placement practice, are there environmental implications to consider (Borges and Mallarino, 2000)?

Residual Soil P Distribution

Residual Soil P Distribution

Subsampling of monoliths to characterize.



Results

Residual MK Extractable Phosphorus (mg P kg soil^{-1})

Distribution in soil after soybean harvest in September

	10 cm	5 cm	Seed-row	5 cm	10 cm
1 cm	13.4	12.8	9.8	11.2	17.4
4 cm	5.7	5.9	4.3	4.1	4.6
7 cm	1.4	1.5	1.6	1.4	1.7
10 cm	1.4	1.3	1.5	1.4	1.8

Control (No P Fert)

	10 cm	5 cm	Seed-row	5 cm	10 cm
1 cm	12.2	16.4	13.8	27.6	8.9
4 cm	7.7	15.2	9.4	18.3	8.1
7 cm	3.4	3.5	1.7	3.1	2.2
10 cm	1.8	1.7	1.5	1.9	1.6

Broadcast (20 kg P_2O_5/ha)

	10 cm	5 cm	Seed-row	5 cm	10 cm
1 cm	13.4	12.8	9.8	11.2	17.4
4 cm	5.7	5.9	4.3	4.1	4.6
7 cm	1.4	1.5	1.6	1.4	1.7
10 cm	1.4	1.3	1.5	1.4	1.8

Control

	10 cm	5 cm	Seed-row	5 cm	10 cm
1 cm	21.8	23.4	14.7	45.4	21.5
4 cm	14.4	18.1	16.2	14.3	12.5
7 cm	2.8	1.9	1.7	1.9	1.4
10 cm	2.0	1.5	1.5	1.5	1.8

Broadcast (40 kg P_2O_5/ha)

	10 cm	5 cm	Seed-row	5 cm	10 cm
1 cm	13.4	12.8	9.8	11.2	17.4
4 cm	5.7	5.9	4.3	4.1	4.6
7 cm	1.4	1.5	1.6	1.4	1.7
10 cm	1.4	1.3	1.5	1.4	1.8

Control (No P Fert)

	10 cm	5 cm	Seed-row	5 cm	10 cm
1 cm	14.5	15.6	12.0	10.8	
4 cm	5.7	8.3	8.6	6.8	12.6
7 cm	2.0	2.9	3.9	5.8	10.2
10 cm	1.9	2.2	1.9	2.0	1.8

Broadcast with Incorporation (20 kg P_2O_5/ha)

	10 cm	5 cm	Seed-row	5 cm	10 cm
1 cm	13.4	12.8	9.8	11.2	17.4
4 cm	5.7	5.9	4.3	4.1	4.6
7 cm	1.4	1.5	1.6	1.4	1.7
10 cm	1.4	1.3	1.5	1.4	1.8

Control (No P Fert)

	10 cm	5 cm	Seed-row	5 cm	10 cm
1 cm	5.3	8.5	20.7	12.8	9.6
4 cm	3.4	6.5	13.0	9.2	5.6
7 cm	1.6	2.1	2.0	3.0	2.2
10 cm	1.1	1.6	2.4	2.7	2.0

Seed Placed (20 kg P_2O_5/ha)

	10 cm	5 cm	Seed-row	5 cm	10 cm
1 cm	13.4	12.8	9.8	11.2	17.4
4 cm	5.7	5.9	4.3	4.1	4.6
7 cm	1.4	1.5	1.6	1.4	1.7
10 cm	1.4	1.3	1.5	1.4	1.8

Control (No P Fert)

	10 cm	5 cm	Seed-row	5 cm	10 cm
1 cm	10.8	13.8	12.9	13.9	11.6
4 cm	8.5	8.8	11.1	7.0	16.4
7 cm	1.7	14.8	4.3	4.4	6.0
10 cm	1.4	11.4	1.3	1.5	1.7

Deep Band (20 kg P_2O_5/ha)

Discussion

Fertilizer application method influences P distribution in soil profile after harvest.

Enhanced P concentrations near soil surface from broadcast fertilizer application anticipated to promote off-site transport in runoff water.

Considerable micro-scale variability in soil P concentrations present. This agrees with previously conducted research in no-till fields (Hu et al., 2014).

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